the macro-dispersion achievable by prior known techniques and equipment exemplified by Asai et al, Inoue et al and Simonet et al. And yet Bohm et al boasts numbers which fall an order of magnitude short of the present invention.

Conclusion

Applicants request that the rejection of the claims be withdrawn, and submits that the claims remaining under consideration in the application are now in condition for allowance, which action is respectfully requested.

Respectfully submitted,
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January 28, 1999
Date

Peter D. McDermott

ATTACHMENT A

Allowed Claims from Parent Patent Application USSN 08/625,163

1. A method of producing elastomer masterbatch, comprising:

feeding a continuous flow of first fluid comprising elastomer latex to a mixing zone of a coagulum reactor defining an elongate coagulum zone extending from the mixing zone to a discharge end;

feeding a continuous flow of second fluid comprising particulate filler under pressure to the mixing zone of the coagulum reactor to form a mixture with the elastomer latex, the mixture passing as a continuous flow to the discharge end and the particulate filler being effective to coagulate the elastomer latex, wherein mixing of the first fluid and the second fluid within the mixing zone is sufficiently energetic to substantially completely coagulate the elastomer latex with the particulate filler prior to the discharge end; and

discharging a substantially continuous flow of elastomer masterbatch from the discharge end of the coagulum reactor.

2. The method of producing elastomer masterbatch in accordance with claim 1 wherein the second fluid is fed to the mixing zone through a nozzle at a velocity of 100 to 600 feet per second.

3. The method of producing elastomer masterbatch in accordance with claim 2 wherein the first fluid is fed continuously into the mixing zone at a velocity lower than 12 feet per second.

4. The method of producing elastomer masterbatch in accordance with claim 1 wherein the elastomer latex is natural rubber latex and the particulate filler is carbon black.

5. The method of producing elastomer masterbatch in accordance with claim 1 further comprising feeding an auxiliary fluid to the mixing zone, the auxiliary fluid being substantially non-reactive with the mixture.

6. The method of producing elastomer masterbatch in accordance with claim 5 wherein the auxiliary fluid is air.

7. The method of producing elastomer masterbatch in accordance with claim 1 wherein the coagulum zone has progressively increasing cross-sectional area.

8. A continuous flow method of preparing elastomer masterbatch of particulate filler dispersed in elastomer, comprising:

A) establishing a continuous, semi-confined flow of mixed elastomer latex and particulate filler under pressure in a coagulum reactor forming an elongate coagulum zone extending with progressively increasing cross-sectional area from an entry end to a discharge end, by simultaneously

(i) feeding elastomer latex fluid continuously to a mixing zone at the entry end of the coagulum reactor, and

(ii) entraining the elastomer latex fluid into particulate filler fluid by feeding the particulate filler fluid as a continuous jet into the mixing zone; and

B) discharging from the discharge end of the coagulum reactor a substantially constant flow of elastomer masterbatch globules concurrently with feeding of the fluid streams in accordance with steps A(i) and A(ii).

9. The continuous flow method of producing elastomer masterbatch in accordance with claim 8 wherein coagulation of the elastomer latex is substantially complete in the elastomer masterbatch globules as they are discharged from the discharge end of the coagulum reactor.

10. The continuous flow method of producing elastomer masterbatch in accordance with claim 8 further comprising the step of preparing the particulate filler fluid by high energy dispersion of the particulate filler in a liquid in a homogenizer having an outlet port in fluid communication with the mixing zone.

11. The continuous flow method of producing elastomer masterbatch in accordance with claim 8 wherein the liquid slurry is fed into the mixing zone through a nozzle at a velocity of 100 to 600 feet per second.

12. The continuous flow method of producing elastomer masterbatch in accordance with claim 11 wherein the velocity of the liquid slurry through the nozzle is from 200 to 500 feet per second.

13. The continuous flow method of producing elastomer masterbatch in accordance with claim 8 further comprising the step of premixing minor amounts of additives into the elastomer latex prior to feeding the elastomer latex to the mixing zone.

14. The continuous flow method of producing elastomer masterbatch in accordance with claim 8 wherein the particulate filler fluid is an aqueous carbon black dispersion.

15. The continuous flow method of producing elastomer masterbatch in accordance with claim 8 wherein the particulate filler fluid comprises particulate filler selected from the group consisting of silicon treated carbon black, fumed silica, precipitated silica, and mixtures of any of them.

16. The continuous flow method of preparing elastomer masterbatch in accordance with claim 8 wherein the elastomer latex fluid consists essentially of natural rubber latex.

17. The continuous flow method of preparing elastomer masterbatch in accordance with claim 16 wherein the natural rubber latex is natural rubber latex concentrate.

18. The continuous flow method of preparing elastomer masterbatch in accordance with claim 16 wherein the natural rubber latex is field latex.

19. The continuous flow method of producing elastomer masterbatch in accordance with claim 8 further comprising mixing additive to the semi-confined flow by separately feeding an additive fluid continuously to the mixing zone simultaneously with the elastomer latex fluid and the particulate filler fluid.

20. The continuous flow method of producing elastomer masterbatch in accordance with claim 8 wherein the additive is selected from antiozonants, antioxidants, plasticizers, processing aids, resins, flame retardants, extender oils, lubricants, and mixtures of any of them.

21. The continuous flow method of producing elastomer masterbatch in accordance with claim 8 further comprising injecting pressurized gas into the mixing zone.

22. The continuous flow method of producing elastomer masterbatch in accordance with claim 21 wherein the pressurized gas is injected separately into the mixing zone.

23. The continuous flow method of producing elastomer masterbatch in accordance with claim 22 wherein the pressurized gas is injected into the mixing zone through a nozzle together with the particulate filler fluid.

24. The continuous flow method of producing elastomer masterbatch in accordance with claim 8 wherein step A(ii) comprises feeding multiple streams of particulate filler fluid to the mixing zone continuously through multiple nozzles.

25. The continuous flow method of producing elastomer masterbatch in accordance with claim 8 further comprising, simultaneously with steps A(i) and A(ii), feeding at least one auxiliary stream of elastomer latex fluid to the mixing zone.

26. The continuous flow method of producing elastomer masterbatch in accordance with claim 8 further comprising the step of drying the elastomer masterbatch globules received from the discharge end of the coagulum reactor, through a series of multiple dryers.

27. The continuous flow method of producing elastomer masterbatch in accordance with claim 26 further comprising the step of baling the elastomer masterbatch by sequentially compressing 25 to 75 pound quantities of the elastomer masterbatch after the drying step.

28. The continuous flow method of producing elastomer masterbatch in accordance with claim 8 wherein the elastomer latex fluid is fed under pressure less than 10 psig and the particulate filler fluid is fed under pressure of at least 75 psig.

29. A continuous flow method of producing rubber masterbatch by coagulating natural rubber latex with carbon black, comprising:

A) establishing a continuous, semi-confined flow of mixed natural rubber latex and carbon black in a coagulum reactor forming a generally tubular coagulum zone extending with progressively increasing cross-sectional area from an entry end to an open discharge end, by simultaneously

(i) feeding a liquid stream of the natural rubber latex continuously to a mixing zone at the entry end of the coagulum reactor, and

(ii) entraining the natural rubber latex continuously into a liquid slurry of the carbon black by feeding the liquid slurry as a continuous jet into the mixing zone; and

B) simultaneously discharging rubber masterbatch globules from the discharge end of the coagulum reactor.

30. A continuous flow method of producing elastomer masterbatch comprising particulate filler selected from carbon black, silicon-treated carbon black, fumed silica, precipitated silica, and mixtures thereof finely dispersed in natural rubber, comprising:

preparing a particulate filler fluid by high energy dispersion of the particulate filler into aqueous liquid in a homogenizer; and

establishing a continuous, semi-confined flow of mixed natural rubber latex and particulate filler in a coagulum reactor forming a generally tubular coagulum zone extending with progressively increasing cross-sectional area from an entry end to a discharge end by simultaneously

(i) feeding a liquid stream of the natural rubber latex at less than 10 feet per second continuously to a mixing zone defined by a mix head in sealed fluid communication with the entry end of the coagulum reactor, the mixing zone extending coaxially with the coagulum zone, and

(ii) entraining the natural rubber latex continuously into the particulate filler fluid by feeding the particulate filler fluid into the mixing zone toward the entry end of the coagulum zone, through a feed tube substantially coaxial with the coagulum zone, the particulate filler fluid exiting the feed tube at a velocity of 200 to 500 feet per second;

simultaneously and continuously discharging from the discharge end of the coagulum reactor masterbatch globules in which coagulation of the natural rubber latex by the particulate filler is substantially complete; and

simultaneously and continuously drying and pelletizing masterbatch globules discharged from the coagulum reactor in a series of dryers.

31. Apparatus for producing elastomer masterbatch of particulate filler dispersed in elastomer, comprising:

a coagulum reactor defining a mixing zone and an elongate coagulum zone extending from the mixing zone to a discharge end;

latex feed means for feeding elastomer latex fluid continuously to the mixing zone; and

filler feed means for feeding particulate filler fluid as a continuous jet into the mixing zone to form a mixture with the elastomer latex fluid traveling from the mixing zone to the discharge end of the coagulum zone, with substantially complete coagulation of the elastomer latex prior to the discharge end.

32. The apparatus for producing elastomer masterbatch in accordance with claim 31 wherein the filler feed means is for feeding particulate filler fluid continuously to the mixing zone through a nozzle at a velocity of 100 to 600 feet per second.

33. The apparatus for producing elastomer masterbatch in accordance with claim 32 wherein the latex feed means is for feeding elastomer latex fluid continuously into the mixing zone at a velocity less than 8 feet per second.

34. The apparatus for producing elastomer masterbatch in accordance with claim 31 wherein the filler feed means is for feeding particulate filler fluid continuously to the mixing zone under pressure of at least 75 pounds per square inch (guage).

35. The apparatus for producing elastomer masterbatch in accordance with claim 34 wherein the latex feed means is for feeding elastomer latex fluid continuously into the mixing zone under pressure less than 12 pounds per square inch.

36. The apparatus for producing elastomer masterbatch in accordance with claim 31 further comprising auxiliary feed means for simultaneously feeding an additional stream of pressurized fluid to the mixing zone.

37. The apparatus for producing elastomer masterbatch in accordance with claim 36 wherein the pressurized fluid is air.

38. The apparatus for producing elastomer masterbatch in accordance with claim 31 wherein the coagulum zone has progressively increasing cross-sectional area between the mixing zone and the discharge end.

39. Apparatus for continuous flow production of elastomer masterbatch of particulate filler dispersed in elastomer, comprising:

a coagulum reactor forming an elongate coagulum zone extending with progressively increasing cross-sectional area from an entry end toward a discharge end;

means for feeding elastomer latex fluid continuously to a mixing zone at the entry end of the coagulum reactor; and

means for feeding particulate filler fluid sufficiently energetically into the mixing zone to create semi-confined flow of mixed elastomer latex and particulate filler in the coagulum zone toward the discharge end and achieve substantial coagulation of the elastomer latex with the particulate filler prior to the discharge end.

40. Apparatus for producing elastomer masterbatch of particulate filler dispersed in elastomer, comprising:

a coagulum reactor forming an elongate coagulum zone extending with progressively increasing cross-sectional area from an entry end to a discharge end;

means for feeding elastomer latex fluid continuously to a mixing zone at the entry end of the coagulum reactor; and

means for feeding to the mixing zone a continuous jet of particulate filler fluid effective to entrain elastomer latex fluid into an mixture with the particulate filler fluid and to substantially completely coagulate the elastomer latex with the particulate filler prior to the mixture arriving at the discharge end.

41. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 40 wherein the mixing zone is within a mix head and is substantially coaxial with the elongate coagulum zone.

42. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 41 wherein the mix head is sealed to a coagulum zone extender.

43. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 42 wherein the means for feeding a stream of particulate filler fluid comprises a first feed tube extending substantially coaxially within the mixing zone to a nozzle open toward the coagulum zone.

44. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 43 wherein:

the mix head forms a first feed channel substantially coaxial with the coagulum zone, extending from an entry port toward the coagulum zone; and

the first feed tube extending coaxially within the first feed channel forms a fluid tight seal with the mix head at the entry port.

45. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 44 wherein the first feed tube extends from the entry port to a nozzle tip and wherein a constant diameter land within the first feed tube immediately upstream of the nozzle tip has an axial dimension at least three times its diameter.

46. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 44 wherein the means for feeding elastomer latex fluid comprises a second feed channel formed by the mix head at an angle of 30° to 90° to the first feed channel, extending to a junction with the mixing zone from a second entry port remote from the mixing zone.

47. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 45 wherein the cross-sectional area of the coagulum zone immediately downstream of the mixing zone is more than twice the cross-sectional diameter of the first feed tube.

48. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 47 wherein the cross-sectional area of the coagulum zone immediately downstream of the mixing zone is about 4 to 8 times the cross-sectional area of the first feed tube.

49. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 45 wherein the mix head forms at least one additional feed channel at an angle of 30° to 90° to the first feed channel, extending to a junction with the mixing zone from an entry port remote from the mixing zone.

50. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 40 wherein at least a first portion of the coagulum zone extending from the entry end toward the discharge end has a circular cross-section and a central longitudinal axis, the circular cross-section increasing in size at an overall angle greater than zero degrees and less than 25 degrees to the central longitudinal axis.

51. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 40 wherein the cross-sectional area of the coagulum zone increases continuously toward the discharge end.

52. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 50 wherein the cross-sectional area of the coagulum zone increases step-wise from the entry end toward the discharge end.

53. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 51 wherein said first portion of the coagulum zone comprises:

a first section of substantially constant diameter D_1 extending a length L_1 from the entry end toward the discharge end, L_1 being at least three times D_1, and

multiple additional sections each having substantially constant cross-sectional diameter, twice the cross-sectional area of an immediately preceding section, and a length equal to at least three times its cross-sectional diameter.

54. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 53 wherein the length L_1 of the first section is about 12 to 18 times its diameter D_1.

55. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 54 wherein the coagulum zone extending from the entry end toward the discharge end has circular cross-section, increases in size step-wise toward the discharge end, and has:

a first section beginning at the entry end having a substantially constant cross-sectional diameter D_1 equal to 5 to 8 times the cross-sectional diameter of the nozzle, a cross-sectional area A_1, and a length L_1 which is 12 to 18 times D_1;

a second section extending toward the discharge end from a faired connection to the first section, having a substantially constant cross-sectional diameter D_2, a cross-sectional area A_2 approximately two times A_1, and a length L_2 approximately three to seven times D_2;

a third section extending toward the discharge end from a faired connection to the second section, having a substantially constant cross-sectional diameter D_3, a cross-sectional area A_3 approximately two times A_2, and a length L_3 approximately three to seven times D_3; and

a fourth section extending toward the discharge end from a faired connection to the third section, having a substantially constant cross-sectional diameter D_4, a

cross-sectional area A_4 approximately two times A_3, and a length L_4 approximately three to seven times D_4.

56. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 40 further comprising a diverter for receiving elastomer masterbatch from the discharge end of the coagulum zone and passing the elastomer masterbatch selectively to any of multiple receiving sites.

57. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 56 wherein the diverter comprises a flexible conduit having one end attached to the discharge end of the coagulum reactor and a second end moveable to any of the multiple receiving sites.

58. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 56 wherein the means for feeding particulate filler fluid comprises pumping means for developing said pressure to greater than 75 psig and the means for feeding elastomer latex fluid comprises a holding tank and feed line for developing less than 10 psig elastomer latex fluid pressure.

59. The apparatus for continuous flow production of elastomer masterbatch in accordance with claim 40, wherein the particulate filler fluid is carbon black slurry comprising carbon black in a carrier liquid, further comprising carbon black slurry preparation means in fluid communication with the means for feeding particulate filler fluid to the mixing zone, comprising:

a mixing tank for agitated mixture of carbon black and carrier liquid, having a discharge port for discharging a mixture fluid;

a colloid mill for dispersing carbon black in the carrier liquid to form a dispersion fluid, having an intake port in fluid communication with the discharge port of the mixing tank and an outlet port for discharging the dispersion fluid; and

an homogenizer for more finely dispersing the carbon black in the carrier liquid to form the carbon black slurry, having an inlet port in fluid communication with the discharge port of the colloid mill and an exit port for passing carbon black slurry to the means for feeding particulate filter fluid to the mixing zone.

60. An elastomeric composition comprising elastomer in which particulate filler has been dispersed by:

feeding a continuous flow of first fluid comprising elastomer latex to a mixing zone of a coagulum reactor defining an elongate coagulum zone extending from the mixing zone to a discharge end;

feeding a continuous flow of second fluid comprising particulate filler under pressure to the mixing zone of the coagulum reactor to form a mixture with the elastomer latex, the mixture passing as a continuous flow to the discharge end, and the particulate filler being effective to coagulate the elastomer latex, wherein mixing of the first fluid and the second fluid within the mixing zone is sufficiently energetic to substantially completely coagulate the elastomer latex with the particulate filler prior to the discharge end; and

discharging a substantially continuous flow of elastomer masterbatch from the discharge end of the coagulum reactor.

61. An elastomeric composition comprising particulate filler finely dispersed in elastomer, formed by a continuous flow method comprising the steps of:

A) establishing a continuous, semi-confined flow of mixed elastomer latex and particulate filler under pressure in a coagulum reactor forming an elongate coagulum zone extending with progressively increasing cross-sectional area from an entry end to a discharge end, by simultaneously

(i) feeding elastomer latex fluid continuously to a mixing zone at the entry end of the coagulum reactor, and

(ii) entraining the elastomer latex fluid into particulate filler fluid by feeding the particulate filler fluid as a continuous jet into the mixing zone; and

B) discharging from the discharge end of the coagulum reactor a substantially constant flow of elastomer masterbatch globules concurrently with feeding of the fluid streams in accordance with steps A(i) and A(ii).

62. An elastomeric composition formed by a continuous flow method comprising the steps of:

A) establishing a continuous semi-confined flow of mixed natural rubber latex and carbon black in a coagulum reactor forming a generally tubular coagulum zone extending with progressively increasing cross-sectional area from an entry end to an open discharge end, by simultaneously

(i) feeding a liquid stream of the natural rubber latex continuously to a mixing zone at the entry end of the coagulum reactor, and

(ii) entraining the natural rubber latex continuously into a liquid slurry of the carbon black by feeding the liquid slurry as a continuous jet into the mixing zone; and

B) simultaneously discharging elastomer masterbatch globules from the discharge end of the coagulum reactor.

63. An elastomeric composition formed by a continuous flow method comprising the following steps:

preparing a particulate filler fluid by high energy dispersion of the particulate filler into aqueous liquid in a homogenizer; and

establishing a continuous, semi-confined flow of mixed natural rubber latex and particulate filler in a coagulum reactor forming a mixing zone and a generally tubular coagulum zone extending with progressively increasing cross-sectional area from the mixing zone to a discharge end by simultaneously

(i) feeding a liquid stream of the natural rubber latex at less than 10 feet per second continuously to a mixing zone defined by a mix head in sealed fluid communication with a coagulum zone extender, the mixing zone extending coaxially with the coagulum zone, and

(ii) entraining the natural rubber latex continuously into the particulate filler fluid by feeding the particulate filler fluid into the mixing zone through a feed tube substantially coaxial with the coagulum zone, the particulate filler fluid exiting the feed tube at a velocity of 200 to 500 feet per second;

simultaneously and continuously discharging from the discharge end of the coagulum reactor globules of the elastomeric composition in which coagulation of the natural rubber latex by the particulate filler is substantially complete; and

simultaneously and continuously drying and pelletizing globules discharged from the coagulum reactor.

64. An elastomeric composition comprising natural rubber and 25 to 75 phr carbon black having structure and surface area ratio DBP : I_2No less than 1.2 having at least Cabot Dispersion Rating of at least A3 measured by ASTM D2663 method.

65. An elastomeric composition comprising natural rubber and carbon black, wherein the carbon black has structure and surface area ratio DBP : I_2No less than 1.0 and the composition has macro-dispersion of the carbon black to a degree of at least Cabot Dispersion Rating A1 measured by ASTM D2663 method.

66. Tire tread comprising elastomeric composition in accordance with any of claims 60 to 65.

67. Cured elastomer compound comprising the cured product of elastomeric composition in accordance with any of claims 60 to 65.